Fergusson's Percentage Unit of Angular Measurement, with Logarithms; also a Description of his Percentage Theodolite and Percentage Compass. By JOHN COLEMAN FERGUSSON. London, Longmans, Green & Co. 1912. 8vo. Pp. lxvii + 467.

This is one of those costly volumes printed occasionally to advocate some novel idea; not actually incorrect, but yet quite without real value. Such books are full of pathos. One can see in their pages lost yet endless industry; painful longing for sympathetic appreciation; indomitable energy; the sacrifice almost of a life-time; and finally the refusal to accept even the kindliest adverse criticism. Were not the theories of Galileo received with incredulity? Are not my theories met by similar unbelief? Galileo was right. So then must I be also. Such is the fallacious reasoning consciously or unconsciously in the minds of men like Fergusson.

The division of the circle has always been made hitherto in equal parts, ordinary degrees of arc or centesimal degrees. Fergusson proposes to divide the circle into unequal parts, one hundred spaces to each octant, or arc of 45° as ordinarily measured. To the new divisions will be attached numbers thus: 1%, 2%, . . . 10%, etc., in such a way that the number 10%, for instance, will belong to the angle whose tangent is 0.10, etc.

The author gives elaborate logarithmic tables computed for this new division of the circle; but it appears from his examples of their use that no saving of time or other advantage has been obtained. He has also had made an engineer's angle instrument provided with the new circle divisions; and has of course been unable to use a vernier. In its place is substituted a most complicated "micrometer drum screw."

The book is not free from humor: we recommend the following passage to the engineering and financial experts of Wall Street.

"*A* gives *X* £500 sterling for a half share in the sixth interest that *X* holds in a mining claim located at Eureka, Nevada, U. S. A. It is plain to everybody that *X* has received £500 sterling for the half share of his mining interest. *A*, on the other hand, has got for his money an acknowledgment, which, in itself, is a concrete function implying value; and this implied value is dependent on the geological formation of a piece of ground staked out in Nevada, the true value of which *A* may determine by the aid of a Philadelphia lawyer and a western mining expert. *A* has received *implicit* value; *X* got *explicit* value."

The author asserts that this "simple example" makes clear "the whole difference between the arithmetical and algebraic systems."

H. J.

SPECIAL ARTICLES

THE PRESENT STATUS OF THE BACTERIOLOGY OF HUMAN LEPROSY

SINCE the discovery by Hansen in 1872 of an acid-fast bacillus in the leprous lesion to which he ascribed an etiological rôle, numerous investigators have reported success with its artificial cultivation. It may be stated, however, that prior to 1901 the cultures isolated and described by various investigators differed tinctorially and morphologically from the Hansen bacillus of the tissues, and although many of these cultures were said to have induced experimental lesions similar to human leprosy and to have fulfilled other postulates, no one of them has been universally accepted as the specific organism of leprosy.

Kedrowski in 1901 described an organism which he cultivated from the leprous lesion and believed to be the specific bacillus of leprosy. This author reported his culture as a non-acid fast diphtheroid bacillus, which when injected into laboratory animals became acid-fast after a sojourn of weeks in the tissues. He advanced the theory that the acid-fast rods seen in human leprous lesions represent but a stage in the developmental cycle of a single pleomorphic species.

Deycke and Rost and Williams have since reported (1905) upon the successful cultivation from the leprous nodule of an organism similar to that of Kedrowski's together with which they also found streptothrical forms and acid-fast rods.

More recently Bayon (1912) describes a non-acid-fast diphtheroid obtained from a leper which behaves in a like manner to Kedrowski's culture, *i. e.*, the initial growth from the tissues is non-acid-fast and a diphtheroid until passed through rats, after which it permanently changes into a typical acid-fast bacillus. Like Rost and Williams he also mentions streptothrical forms in his culture. He concludes that not only is his culture identical with Kedrowski's, but also that it is the cause of human leprosy, basing his argument upon specific reactions obtained with human leper serum and also upon the production of characteristic lesions in laboratory animals.

Clegg in 1909 announced his success in the cultivation of an acid-fast bacillus which he isolated from lesions in a large series of lepers in the Philippines. He found that multiplication in each instance occurred in the transferred leprous tissue bits when planted with amœbæ and their symbionts. He subsequently obtained pure cultures of acid-fast organisms on the ordinary laboratory media as a moist, profuse, pigmented growth after heating at 60° C. for 30 minutes to kill out the symbionts.

The author (1910) described a method by which the bacilli in the leprous lesion could be cultivated in vitro without the use of symbionts. The culture differed from Clegg's in that it did not produce pigment and it refused to grow except upon special nutrients; however, cultures were subsequently isolated from a number of cases which in time became rapid growers and chromogenic. Other cultures similar to Clegg's have been reported by Brinkerhoff and Currie in Honolulu, Rivas in Philadelphia, Thompson in Australia, Wellman in California and workers in Hawaii.

The work of Rost, Williams, Kedrowski, Bayon and others, who have cultivated organisms other than acid-fast rods from leprous lesions, tends to show that the organism of leprosy is "an extremely pleomorphic streptothrix" which under certain circumstances may be: (1) A non-acid-fast streptothrix with interlacing filaments, (2) a non-acid-fast diphtheroid bacillus, which is in reality a streptothrix, and capable of becoming acid-fast under certain conditions, (3) a definite acid-fast filamentous streptothrix, or (4) an acid-fast bacillus which is the broken-down stage of a streptothrix.

A review of the literature would seem to show that three or possibly four apparently different germs have been cultivated and described as the causal agent of human leprosy; namely, (1) a non-acid-fast diphtheroid (Kedrowski), (2) an acid-fast chromogenic bacillus (Clegg), (3) non acid-fast and acid-fast interlacing and filamentous streptothrix (Rost & Williams), and (4) a bacillus which *in vitro* maintains the morphology and staining reaction of the Hansen bacillus of the tissues and grows under artificial conditions only in the presence of special nutrients (Duval).

Acid-fast and non-acid-fast filamentous forms I have also encountered in certain of the cultures which become chromogenic and rapid growers, but branching non-acid-fast streptothrices I have never noted in the acid-fast culture which is non-chromogenic and refuses to multiply except upon special media.

The marked variation in morphology and staining properties of the chromogenic culture I have regarded as involution or degeneration forms of the species. However, it is noteworthy that by plating out the chromogenic culture, separate colonies of non-acid-fast streptothrices and non-acid-fast diphtheroids are recovered, and these are converted into acid-fast rods by alterations in the reaction of the medium, etc.

Since we may encounter in the leprous lesion a pleomorphic organism which is capable of changing in vitro under defined conditions, it is easy to explain the bewildering number of "stages" for the supposedly cultivated Hansen bacillus of some writers.

Whether the various cultures reported as the Hansen bacillus represent the same or distinct species, some one of which is the real exciter of leprosy and the others simply extraneous or accidental commensals, is a problem yet unsolved; however, by a comparative

study of the lesions induced experimentally, the behavior of the cultures with respect to immune sera and by other well-known methods it is hoped that the proper status of the various cultures will be established.

In Louisiana I have attempted the cultivation of the Hansen bacillus from 29 cases of leprosy and have succeeded in isolating an acid-fast bacillus from 22 of these cases. The chromogenic variety was recovered from 14 cases while 8 yielded a non-chromogenic acid-fast bacillus which thus far has refused to produce pigment or multiply on the ordinary laboratory media, and in one case a non-acid-fast diphtheroid was recovered.

For many generations the sub-plants both of the chromogenic and of the non-pigment producing types have each remained well within the variations of a species and have in general maintained very closely the morphology of the Hansen bacillus as we know it in the tissues.

In the 14 cases above mentioned the acid-fast culture recovered has eventually undergone a marked change in morphological and cultural features after which it could be propagated upon the ordinary laboratory media. These cultures which become chromogenic correspond in all essentials to Clegg's original isolation.

In the 8 cases referred to, the non-chromogenic culture, although behaving much as did the Clegg chromogenic bacillus for the first two or three months under artificial growth conditions, has refused to produce pigment or grow on ordinary media.

Since the chromogenic culture behaved much in the same manner as the non-chromogen during the first three or four months of artificial cultivation, I have looked for a similar change to occur in this particular "slow-growing" strain. It would seem that it will not become saprophytic as the period of parasitism experienced with the cultures which subsequently became chromogenic and distinctly vegetative has long passed.

It is hard to explain the occurrence in the leprous lesion of the chromogenic acid-fast, which in my experience with cases here is encountered more frequently than the non-chromogenic variety. Curiously enough the chromogenic type, if we are to regard it as an extraneous organism, is always the same variety, that is, a moist rapidly growing diplococcoid bacillus when once it becomes accustomed to an artificial environment. I have compared the seven original cultures of Clegg, and those isolated independently by workers in Hawaii, Honolulu and London with the chromogenic cultures isolated here and find them identical except for minor inconstant differences. That the chromogen exists in the lesion of certain types of leprosy there can be no doubt, even where the overlying skin is apparently intact, and also in the internal organs at autopsy, more particularly the spleen. If these cultures are extraneous saprophytes it is hard to explain that they should occur in so large a percentage of cases. Of course it is well known how ubiquitous are the saprophytic acid-fast species, it being possible to isolate them from almost any source outside the animal body. Their occasional occurrence, therefore, in the open skin lesion of leprosy is to be expected, but to find them so frequently is difficult to explain if we are to accept that they are in no way concerned in leprosy.

The initial multiplication in vitro of both the acid-fast strains referred to is accomplished with comparative ease, provided that the bits of leprous tissue transferred are treated in such a way that the protein moiety is split into its dissociate products.

This action upon the protein of the removed leprous lesion may be accomplished in the following ways: (1) By seeding the tissue transplants with some one of the putrefactive bacteria or with any species capable of hydrolyzing the tissues; (2) by saturating the removed tissue bits with a one-per-cent. trypsinized albumen solution; or (3) by transferring the leprous material directly to a medium containing the products of protein digestion.

With any of these methods the acid-fast bacilli in bits of the removed lesion will multiply and continue to do so as long as these products are present.

To establish, if possible, an etiological rôle for any one of the cultures obtained from the human leprous lesion to the exclusion of others, careful comparative studies of the experimentally induced lesion and the serological tests have been carried out upon a large series of animals.

In general it may be stated that macroscopically the lesions produced in the lower animals do not differ greatly for any of the cultures employed, unless it be that the chromogenic type produces lesions which appear earlier and are more localized. Microscopically the cell picture or relation of the bacilli to the cells is not sufficiently distinctive of any culture to warrant more than a tentative differentiation.

In other words the experimental lesions in animals afford no absolute differentiation for any strain of acid-fast organism except of course the tubercle family. Leprous-like lesions are as readily induced experimentally with some of the well-known saprophytic species as they are induced with either the infested leprous tissues or with the lepra culture.

The serological tests with the blood of lepers has not established an etiological rôle for any type of acid-fast organism recovered from the leprous lesion. The agglutination reaction with the lepers' blood rarely gives a positive reaction in dilution of 1/50 with the separated Hansen bacilli obtained from the human nodule, while in the majority of cases a reaction is not obtained above a dilution 1/10. On the other hand, many of the tubercle family and the acid-fast saprophytes react equally as well and not infrequently in higher dilutions. The complement deviation tests with culture antigen utterly fail to show anything specific for the various cultures in so far as the human serum is concerned. However, the serum reaction of animals immunized against the various acid-fast species has served to separate into three distinct groups the chromogenic culture of leprosy (Group I.), the author's non-chromogenic culture of leprosy (Group II.) and the chromogenic saprophytic acid-fast species (Group III.). The reaction with specific immune sera establishes the fact that there is a difference between the non-chromogenic and the chromogenic leprosy cultures. Furthermore the serum reaction indicates no relation between these two strains and no relation of either to any known saprophytic species.

SUMMARY AND CONCLUSIONS

There may be cultivated from the leprous lesion two types of acid-fast bacilli which have distinct characteristics: one an organism which after it has become accustomed to a saprophytic existence produces pigment and becomes extremely pleomorphic; the other a bacillus growing slowly and only upon special media, and retaining always the tinctorial properties of the Hansen bacillus of the tissues. Non-acid-fast diphtheroids are occasionally encountered in the external lesions, but are perhaps accidental contaminators.

The acid-fast strain, which subsequently becomes a rapid grower and develops pigment, shows a wide variation in morphology and ability to retain the stain when subjected to decolorizing agents. At times and under certain conditions the individual bacilli are diphtheroid, streptothrical and non-acid-fast. The slow growing non-chromogenic culture is always acid-fast and can be sharply differentiated from the chromogenic culture by its growth features.

The animal experiments undertaken for the purpose of differentiating the acid-fast organisms recovered from the human leprous lesion and to fix their etiological status are not regarded as conclusive.

The serological tests, especially those performed with highly immune sera, have proven of some value and suggest that the bacillus of Clegg is not related to any known saprophytic acid-fast chromogen, and that the non-chromogenic slow-growing culture from leprosy is different both from Clegg's isolation and from all known species of acid-fast bacilli.

The rôle played by the chromogenic bacillus of Clegg in the production of leprosy is as yet an unsettled question.

The non-chromogenic strain, while behav-

ing according to most of our notions regarding a pathogenic organism, has likewise not up to the present been proven to be the cause of leprosy, although I am impressed with the probability of such a rôle being eventually attributed to it, and consider that it deserves more serious attention than any strain so far cultivated from the human leprous lesion.

The wide variation in morphology and staining reaction for the culture recovered from the human leprous lesion which subsequently becomes a rapid grower and chromogenic, might account for the interpretations of Kedrowski, Rost, Williams, Bayon and others that *B. leprœ* is a bacterium of such pleomorphism that it can be recognized as a non-acid-fast diphtheroid, or streptothrix, and as an acid-fast bacillus.

CHARLES W. DUVAL

THE LAGOMORPHS AN INDEPENDENT ORDER

THE order Rodentia, as at present understood, includes two great groups, or suborders, commonly called the Duplicidentata and the Simplicidentata. Marked distinctions between these groups have long been recognized, yet they have been retained in a single order because of (1) a similar development of large scalpriform incisors and (2) certain similarities in the morphology of the brain and reproductive system which have been regarded as determining relationship. It has been argued[1] that these similarities the more surely denote relationship because of their deep-seated nature. When it is remembered, however, that in development of both brain and reproductive system the groups under discussion are very primitive, differing in these respects but slightly from the Insectivora, Chiroptera, Edentata and Marsupialia, these similarities lose much of their significance, and seem to be far outweighed by the many differences of other early acquired anatomical specializations, especially of the skull and feet. These differences gain in importance when it is considered that, whereas the Simplicidentata are an exceedingly diversified group, both in life and food habits and consequent morphological modifications, while both groups have an almost world-wide distribution, yet there are no known connecting links or intermediate forms, either living or extinct, even though such forms as the jerboas among the true rodents have outstripped the Lagomorphs in specialization for the leaping mode of progression. Paleontological evidence is admissibly very incomplete, yet so far as it goes it indicates clearly two important facts: first that both groups under discussion are of very ancient origin, the known forms showing but slight modification from the early Oligocene up to the present day, and second that in both groups the scalpriform incisor teeth were very early acquired. The latter fact through early limiting their food habits to a certain degree may account in a large measure for the retention in each group of similar primitive characters. In other and widely differing orders scalpriform incisors have been independently acquired, as in the toxodonts, the pyrotheres, the lemurs (*Daubentonia,* aye-aye), the allotheres (*Polymastodon*), the tillodonts and the hyracoids. Even among the artiodactyls a close approximation to this form of incisor has been reached, in the lower jaws, by such forms as the llama and the aberrant goat, *Myotragus.* This character, therefore, is not peculiar to the lagomorphs and rodents, and may very well have been quite independently acquired by these groups. Moreover, certain peculiarities in the structure and development of the incisors in the lagomorphs suggest the truth of this assumption.

Since, therefore in our present state of knowledge there is apparently no good reason for continuing the association of these two great groups of mammals and since, owing to the great number of important differences between them, it is far more convenient for purposes of classification and comparison with other forms to consider them separately, there seems ample reason for placing the Duplicidentata in an independent order. This new order may be called the Lagomorpha, adopting the old subordinal name given to this group by Brandt.

[1] Gregory, *Bull. Amer. Mus. Nat. Hist.,* Vol. 27, p. 325, 1910.